New introduction to the description

Illumination device for backlighting an image reproduction device

The invention relates to an illumination device for backlighting an image reproduction device containing light valves, luminous spots formed by a plurality of light emitting diodes in each case being arranged in grid form.

Image reproduction devices having light valves, in particular liquid crystal displays, require sufficiently bright and uniform backlighting. This is achieved by means of fluorescent tubes in the case of relatively large displays, such as computer screens for example. The known illumination devices do not suffice, however, in applications requiring a very high luminance. Thus, a very high luminance is required for so-called head-up displays in motor vehicles, by way of example, since the reflected image of the display must still be visible even when there is high ambient brightness.

GB 2 361 581 shows an arrangement having a light emitting diode which is arranged in a depression of a heat-dissipating substrate. A plurality of such substrates may be arranged in grid form, a printed circuit connecting all light emitting diodes and substrates to one another. However, this arrangement is difficult to produce; in particular, connecting individual light emitting diodes in series is impossible.

Therefore, it is an object of the invention to specify

an illumination device which has a high luminance on a given area. This object is achieved according to the invention by virtue of the fact that the light emitting diodes of a respective luminous spot

are applied in an electrically insulated manner on the essentially planar surface of a submount, and that the submounts have good thermal conductivity and are connected to a flat thermally conductive carrier in a manner exhibiting good thermal conductivity.

The invention advantageously exploits the fact that a multiplicity of small light emitting diodes emit more light than a correspondingly large diode since the entire free surface area of the light emitting diode emits radiation. The invention additionally ensures good heat dissipation.

One advantageous development of the illumination device according to the invention consists in the fact that the area of the submounts is in each case less than the area provided by the grid, and that lines for supplying power to the light emitting diodes are arranged between the submounts on an insulating carrier on that area of the carrier which is not occupied by submounts. This enables an advantageous thermally conductive connection between the light emitting diodes and the carrier without the lines applied in an insulated manner impeding the heat conduction.

This development may advantageously be refined by the lines being routed in a flexible film that is continued as a flat lead outside the carrier. This means that no further contact-connection is necessary apart from the contact-connection of the lines to the light emitting diodes within the illumination device, which contributes to operational reliability and to inexpensive producibility.

Preferably the invention provides for the submounts to be composed of silicon. In order to further improve the heat dissipation, the invention may provide for

the carrier to be composed of ultrapure aluminum or copper and/or for the carrier to be connected to a heat sink. An example of a suitable heat sink is a large cooling element that emits heat to the surrounding air over a largest possible surface area. Furthermore, so-called heat pipes are suitable as a heat sink.

Furthermore, the illumination device according to the invention preferably provides for interspaces between the submounts to be filled with plastic.

For backlighting a monochrome display, the light emitting diodes may be identically colored. In order to obtain a color that is not available as a light emitting diode or for backlighting a color display, one development provides for the light emitting diodes of a respective luminous spot to emit varicolored light.

The use of a plurality of light emitting diodes for a respective luminous spot has the advantage of a higher luminous efficiency compared with a larger light emitting diode. It has proved to be expedient for four light emitting diodes to form a luminous spot. A different number of light emitting diodes per luminous spot is also possible, however, in the context of the invention.

Another advantageous refinement consists in the fact that two green-luminous light emitting diodes, one blue-luminous and one red-luminous light emitting diode are provided per luminous spot. Although this emphasizes the green component of the generated light compared with the other components, this is necessary

in order to obtain white, for example approximately 60% green, 25% red and 15% blue.

Arranging the luminous spots on submounts has the advantage that the side walls of the light emitting diodes are elevated completely above the lines routed between the luminous spots, so that the radiation emerging therefrom can be utilized. In order to utilize the latter for backlighting the display, another development of the invention provides for the luminous spots to be surrounded by a respective reflector. It is preferably provided in this case that a depression that is formed by the reflector and contains the luminous spot is filled with a transparent plastic.

The light source according to the invention has a high efficiency, long service life, high reliability in respect of failure, defined emission and - when varicolored light emitting diodes are used - a narrowband emission in different colors. It is thus possible to match the spectral emission of the light source and spectral transmission of the color filters of the liquid crystal display and to keep down the light losses due to the color filters. The high efficiency of the light emitting diodes results in a high intensity in conjunction with little generation of heat.

The uniform distribution of the color spots over the entire visible area, in conjunction with a suitable focusing device, results in a further effective increase in the luminance. In this case, the uniform distribution of the luminous spots over the entire visible area results in a uniform luminance distribution which can be increased further by the focusing device. The compact arrangement of the light emitting diodes in a respective luminous spot results in good color mixing. The white-reflective area and the reflector form mean that light which is then emitted at

a less favorable angle is utilized. The use of very

small light emitting diodes results in a compact arrangement having a thickness of a few millimeters, for example 2 mm.

The light emitting diodes require a very low operating voltage, with the result that a plurality of light emitting diodes are expediently connected in series. In the event of one of said light emitting diodes failing, the others are no longer supplied with power and likewise fail. In order to reduce or even to preclude, if appropriate, a visibility of this effect, another development of the illumination device according to the invention provides for a respective light emitting diode of one luminous spot with a respective light emitting diode of a plurality of other luminous spots, connected in series, to form an electric circuit.

In order in this case to prevent particular disturbing stripes or dots from arising in the event of a light emitting diode failing, this development may be designed in such a way that the luminous spots whose light emitting diodes are associated with a respective electric circuit are interleaved with luminous spots of at least one other electric circuit. The interleaving makes it possible, with suitable optical light distribution means, to make the failure of a group hardly visible.

Another advantageous refinement of this development consists in the fact that when a plurality of identically colored light emitting diodes are present per luminous spot, the identically colored light emitting diodes are connected to different electric circuits. Without further measures, a brightness and color change occurs in this case which can be tolerated

for many applications.

However, the color change can be compensated for by virtue of the fact that control devices are provided for the currents fed to the individual electric circuits, which control devices, in the event of interruption

of one of the electric circuits for identically colored light emitting diodes, control the currents in the electric circuits for the at least one other electric circuit for identically colored light emitting diodes and for differently colored light emitting diodes of the same luminous spots in the sense of compensating for the color shift brought about by the interruption.

Insofar as it is possible with regard to the permissible power loss of the affected light emitting diodes, it may be provided in this case that the current in the at least one other electric circuit for identically colored light emitting diodes is increased. With this measure, both the brightness and the color can be brought to the original state.

If it is not possible or expedient to increase the power of the remaining identically colored light emitting diodes, then the currents in the electric circuits for differently colored light emitting diodes may be decreased. As a result, although the brightness is reduced, the color can essentially be maintained.

Another advantageous refinement of the development consists in the fact that a grid of 4 x 8 luminous spots having in each case two green-luminous and two red-luminous light emitting diodes is present, that four electric circuits are provided for the red-luminous light emitting diodes, two electric circuits in each case being assigned to the light emitting diodes of identical luminous spots which are distributed over the grid in checkered fashion. In this case, it is preferably provided that the green-luminous light emitting diodes are connected to eight electric circuits, in each case one green-luminous light

emitting diode of eight luminous spots being connected to one electric circuit and a further green-luminous light emitting diode of the same luminous spots being connected to another electric circuit.

This refinement takes account of the fact that owing to the different voltages required for the red-luminous and the green-luminous light emitting diodes and owing to an expedient operating voltage having a magnitude of approximately 40 V, sixteen red-luminous but only eight green-luminous light emitting diodes are connected in series.

The invention permits numerous embodiments. One of these is illustrated schematically in the drawing using a number of figures and is described below. In the figures:

Figure 1 shows a highly diagrammatic illustration of a display backlit by means of the illumination device according to the invention.

Figure 2 shows a plan view through an exemplary embodiment,

Figure 3 shows an enlarged illustration of one of the luminous spots,

Figure 4 shows a sectional illustration of a luminous spot and of the parts of the exemplary embodiment which surround the luminous spot, and

Figure 5 shows a schematic illustration of the power supply of the light emitting diodes.

New Patent Claims

1. An illumination device for backlighting an image reproduction device containing light valves, luminous spots (6) formed by a plurality of light emitting diodes (9) in each case being arranged in grid form, characterized in that the light emitting diodes of a respective luminous spot (6) are applied in an electrically insulated manner on the essentially planar surface of a submount (10), and in that the submounts (10) have good thermal conductivity and are connected to a flat thermally conductive carrier (7) in a manner exhibiting good thermal conductivity.

2. The illumination device as claimed in claim 1, characterized in that the area of the submounts (10) is in each case less than the area provided by the grid, and in that lines (14) for supplying power to the light emitting diodes (9) are arranged between the submounts (10) on an insulating carrier on that area of the carrier (7) which is not occupied by submounts (10).

3. The illumination device as claimed in claim 2, characterized in that the lines (14) are routed in a flexible film that is continued as a flat lead (8) outside the carrier.

4. The illumination device as claimed in one of the preceding claims, characterized in that the submounts (10) are composed of silicon.

5. The illumination device as claimed in one of one of the preceding claims, characterized in that the carrier (7) is composed of ultrapure aluminum.

6. The illumination device as claimed in one of claims 1 to 4, characterized in that the carrier (7) is composed of copper.

7. The illumination device as claimed in one of one of the preceding claims, characterized in that the carrier (7) is connected to a heat sink.

8. The illumination device as claimed in claim 2, characterized in that interspaces between the submounts (10) are filled with plastic (5, 12).

9. The illumination device as claimed in one of the preceding claims, characterized in that the light emitting diodes (9) of a respective luminous spot (6) emit varicolored light.

10. The illumination device as claimed in one of the preceding claims, characterized in that four light emitting diodes (9) form a luminous spot (6).

11. The illumination device as claimed in claim 10, characterized in that two green-luminous light emitting diodes, one blue-luminous and one red-luminous light emitting diode are provided per luminous spot (6).

12. The illumination device as claimed in one of the preceding claims, characterized in that the luminous

spots (6) are surrounded by a respective reflector (15).

13. The illumination device as claimed in claim 12, characterized in that a depression that is formed by the reflector (15) and contains the luminous spot is filled with a transparent plastic (13).

14. The illumination device as claimed in one of the preceding claims, characterized in that a respective light emitting diode of one luminous spot with a respective light emitting diode of a plurality of other luminous spots, connected in series, form an electric circuit.

15. The illumination device as claimed in claim 14, characterized in that the luminous spots whose light emitting diodes are in each case associated with one electric circuit are arranged in a manner interleaved with luminous spots of at least one other electric circuit.

16. The illumination device as claimed in either of claims 14 and 15, characterized in that a plurality of identically colored light emitting diodes are present per luminous spot, the identically colored light emitting diodes being connected to different electric circuits.

17. The illumination device as claimed in claim 16, characterized in that control devices are provided for the currents fed to the individual electric circuits, which control devices, in the event of interruption of one of the electric circuits for identically colored light emitting diodes, control the currents in the

electric circuits for the at least one other electric

circuit for identically colored light emitting diodes and for differently colored light

emitting diodes of the same luminous spots in the sense of compensating for the color shift brought about by the interruption.

18. The illumination device as claimed in claim 17, characterized in that the current in the at least one other electric circuit for identically colored light emitting diodes is increased.

19. The illumination device as claimed in either of claims 17 and 18, characterized in that the currents in the electric circuits for differently colored light emitting diodes are decreased.

20. The illumination device as claimed in one of claims 14 to 19, characterized in that, a grid of 4 × 8 luminous spots having in each case two green-luminous and two red-luminous light emitting diodes is present, in that four electric circuits are provided for the red-luminous light emitting diodes, two electric circuits in each case being assigned to the light emitting diodes of identical luminous spots which are distributed over the grid in checkered fashion.

21. The illumination device as claimed in claim 20, characterized in that the green-luminous light emitting diodes are connected to eight electric circuits, in each case one green-luminous light emitting diode of eight luminous spots being connected to one electric circuit and a further green-luminous light emitting diode of the same luminous spots being connected to another electric circuit.